UNITED STATES PATENT APPLICATION

TITLE: PROCESS AND APPARATUS FOR BOILING ADD VAPORIZING MULTI-COMPONENT FLUIDS

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RELATED APPLICATIONS

[0001] This application claims provisional priority to United States Provisional Application Serial No. 60/464302 and filing 21 April 2003.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an improved boiler apparatus, systems incorporating the boiler apparatus and to methods for making and using the boiler apparatus and systems incorporating the boiler apparatus.

[0003] More particularly, the present invention relates to an improved boiler apparatus, systems incorporating the boiler apparatus and to methods for making and using the boiler apparatus and systems incorporating the boiler apparatus, where the boiler apparatus includes a vapor removal unit that remove vapor as it boils so that the boiling throughout boiler's length remains substantially nucleate boiling.

2. Description of the Related Art

[0004] In several processes and especially in power systems using multi-component working fluids, it is necessary to completely vaporize such multi-component fluids. However, it is, in practice difficult to completely vaporize such multi-component fluid.

[0005] When a working fluid in the form of a saturated liquid is sent into a boiler, and the quantity of vapor in the stream of working fluid is relatively small, the boiling process is characterized as nucleate boiling. Nucleate boiling has a very high film heat transfer coefficient, but as vapor accumulates, a so-called crisis of boiling occurs. This crisis of boiling results in a drastic fall or reduction in the film heat transfer coefficient.

[0006] On the other hand, when a single-component fluid is vaporized, the liquid can be recycled within the heat exchanger and nucleate boiling can be sustained throughout the entire process. But, such an approach cannot be used with multi-component fluids, because the vapor produced will have a different composition (enriched by the low boiling component) than the remaining liquid resulting in a continuous composition profile across the heat exchanger with the concurrent crises of boiling.

[0007] Thus, if a multi-component fluid needs to be vaporized fully, the in a significant proportion of this vaporization process, *i.e.*, inside the heat exchanger or boiler, nucleate boiling cannot be maintained. Thus, the film heat transfer coefficient in such a process is very low. This results in a very large increase in the required surface of the heat exchanger or boiler.

[0008] If complete vaporization of a multi-component working fluid has to be performed at high temperature, *e.g.*, in a furnace of a power plant, then the inability of the process to maintain nucleate boiling inside heat transfer tubes of the furnace makes such a process technically very difficult.

[0009] When nucleate boiling is maintained, due to a high film heat transfer coefficient, the temperature of the metal of the heat transfer tubes is maintained close to the temperature of the boiling fluid, and as a result the tubes are protected from burn out. However, because in the process of direct vaporization of multi-component working fluids where nucleate boiling cannot be maintained, the heat transfer tubes can achieve unacceptably high temperatures resulting in tube damage or destruction.

[0010] Thus, there is a need in the art for process and apparatus for boiling and vaporization of multi-component fluids designed to achieve the production of vapor of the same composition as the composition of the initial multi-component liquid, and at the same time, to maintain a process of nucleate boiling in the heat transfer apparatus.

SUMMARY OF THE INVENTION

[0011] The present invention provides an improved boiler or heat transfer apparatus including a vapor removal apparatus that removes vapor from a boiling working fluid so that substantially nucleate boiling occurs throughout the heat transfer apparatus and substantially full or complete vaporized of a multi-component working fluid occurs, where the multi-component working fluid comprises a low boiling component and a high boiling component.

[0012] The present invention also provides an improved vaporization apparatus for multi-component working fluids including a plurality of heat transfer apparatuses, each apparatus including a heat exchange unit and a vapor removal or collector unit, where the vapor collector units are adapted to maintain substantially nucleate boiling throughout each heat exchange unit and where the vaporization apparatus converts a liquid multi-component fluid feed having a given composition into a vapor stream having substantially the same composition.

[0013] The present invention provides a system for extracting heat from a heat source and converting a portion of the heat into a useable form of energy including a heat source stream, a multi-component working fluid, a vaporization apparatus of this invention, and a heat extraction

system.

[0014] The present invention provides a method for vaporizing a liquid multi-component working fluid having a given composition into a vapor multi-component working fluid having substantially the same compositions, where the method includes the steps of feeding the liquid multi-component working fluid stream into an improved multi-component working fluid vaporization apparatus of this invention from a energy production facility, inputting a heat source stream from a heat source, outputting an spent heat source stream to the source and sending a vapor multi-component working fluid stream back to the energy production facility, where the liquid multi-component working fluid and the vapor multi-component working fluid have substantially the same composition and the vaporization apparatus maintains substantially nucleate boiling throughout all heat exchange units.

[0015] The present invention provides a methods for vaporizing a multi-component working fluid having a given composition including the steps feeding an input liquid multi-component working fluid stream having a given composition into a first heat transfer apparatus including a first heat exchange unit and a first vapor removal unit and transferring heat from a heat source to the input liquid multi-component working fluid stream to produce a first vapor stream having a richer composition than the input liquid stream and a first liquid stream having a higher temperature and a leaner composition than the input liquid stream. The first liquid stream is forwarded to a second heat transfer apparatus and a including a second heat exchange unit and a second vapor removal unit and transferring heat from the heat source to the first liquid stream to produce a second vapor stream having a richer composition than the first liquid stream and a second liquid stream having a higher temperature and a leaner composition than the first liquid stream. If there are only two heat transfer apparatuses, then the second liquid stream is forwarded to an upper feed port of a scrubber, while the first and second vapor streams can either be combined into to combined vapor stream and forwarded to a lower feed port of the scrubber or forwarded individually to different ports of the scrubber, where the different ports are located based on a temperature of each vapor stream, higher temperature vapor streams are fed at ports higher up a length of the scrubber and lower temperature vapor streams are fed at ports lower down the length of the scrubber. The second liquid stream is preferably sprayed into the scrubber. The second liquid stream and the vapor streams contact each other in a counter-flow arrangement to produce a final vapor stream having a composition substantially identical to the composition the input liquid stream and a remaining liquid stream that is combined with the first liquid stream prior to feeding into the second heat transfer apparatus. For systems having more than two heat transfer apparatuses, each heat transfer apparatus produces a

liquid and vapor stream via heat from the heat source. Each liquid stream is forwarded to the next heat transfer apparatus, while the vapor streams are either combined or individually forwarded to the scrubber along with the last liquid stream from the last heat transfer apparatus. The vapor removal units associated with each heat transfer apparatus insure that substantially nucleate boiling occurs throughout each heat exchange unit.

DESCRIPTION OF THE DRAWINGS

[0016] The invention can be better understood with reference to the following detailed description together with the appended illustrative drawings in which like elements are numbered the same:

[0017] Figure 1A depicts a diagram of a preferred embodiment of a heat transfer apparatus of this invention having a vapor removal apparatus;

[0018] Figure 1B depicts a diagram of another preferred embodiment of a heat transfer apparatus of this invention having a vapor removal apparatus;

[0019] Figure 2A depicts a diagram of another preferred embodiment of a heat transfer apparatus of this invention having a vapor removal apparatus;

[0020] Figure 2B depicts a diagram of another preferred embodiment of a heat transfer apparatus of this invention having a vapor removal apparatus; and

[0021] Figure 3 depicts a diagram of heat extraction and useable energy production facility including a multi-component vaporization apparatus of this invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The inventors have found that a heat transfer apparatus can be constructed for substantially, fully vaporizing a working fluid comprising at least two components one component having a boiling point less than the other component, at least one low boiling component and at least one high boiling component, which includes a vapor removal system adapted to maintain substantially nucleate boiling in a boiling/vaporization zone of the apparatus.

[0023] The present invention broadly relates to an improved boiling apparatus for substantially completely vaporizing a multi-component fluid to obtain a desired vapor stream having a desired temperature and composition, where the boiling apparatus includes a plurality of heat transfer apparatuses and a scrubber, where each heat transfer apparatus comprises a heat exchanger, heat transfer loop or mixture thereof and a vapor removal apparatus. The removal of vapor at each heat transfer stage maintains nucleate boiling in each of the heat transfer apparatuses.

[0024] The present invention also broadly relates to a method for substantially maintaining nucleate boiling through each stage of a multi-stage boiling apparatus including the steps of feeding a multi-

component stream into a plurality of heat transfer apparatuses, each heat transfer apparatus includes a vapor collectors or separator apparatus, where the apparatus allows substantially complete vaporization of the multi-component fluid while maintaining nucleate boiling throughout each heat transfer apparatus.

[0025] The working fluids to be vaporized in the inventions of this application are multi-component fluids that comprises a lower boiling point component fluid – the low-boiling component – and a higher boiling point component – the high-boiling component. Preferred working fluids include, without limitation, an ammonia-water mixture, a mixture of two or more hydrocarbons, a mixture of two or more freon, a mixture of hydrocarbons and freon, or the like. In general, the fluid can comprise mixtures of any number of compounds with favorable thermodynamic characteristics and solubility. In a particularly preferred embodiment, the fluid comprises a mixture of water and ammonia.

[0026] It should be recognized by an ordinary artisan that at those point in the systems of this invention were a stream is split into two or more sub-streams, the valves that effect such stream splitting are well known in the art and can be manually adjustable or are dynamically adjustable so that the splitting achieves the desired improvement in efficiency.

[0027] Suitable heat exchange units include, without limitation, heat exchangers, heat transfer loop, or any other unit that can transfer heat from a heat source to a working fluid stream. Suitable vapor removal units include, without limitation, vapor/liquid separators such as drums or separation tanks, vapor collector or any other unit that can remove a vapor from a mixed vapor-liquid stream.

[0028] The term substantially when used with a composition means that the composition to two streams differs by no more than 5% in each component, preferably, no more than 2% in each component, particularly, no more than 1% in each component and especially, no more than 0.5% in each component, with zero (identical streams) being the ultimate goal. The term substantially when used in conjunction with nucleate boiling means that no more than 10% of the boiling that occurs in the heat exchange units is non-nucleate boiling, preferably, no more than 5% of the boiling that occurs in the heat exchange units is non-nucleate boiling, particularly, no more than 2.5% of the boiling that occurs in the heat exchange units is non-nucleate boiling, especially, no more than 1% of the boiling that occurs in the heat exchange units is non-nucleate boiling, with the ultimate goal being 0% of the boiling that occurs in the heat exchange units is non-nucleate boiling.

[0029] Referring now to Figure 1A, a preferred embodiment of a heat transfer apparatus of this invention, generally **100**, is shown to includes a heat source stream **102** having initial parameters

as at a point **1**, which is forwarded to a third heat exchanger **HE3**. The heat source stream **102** is preferably a hot vapor, liquid or mixed stream such as a geothermal brine stream, a stream from a power plant, or any other stream of hot fluid from any source. The stream **102** passes through heat transfer tubes (not shown) within the third heat exchanger **HE3**, where the stream **102** is cooled, releasing heat and leaves the third heat exchanger **HE3** as a stream **104** having parameters as at a point **2**. Thereafter, the stream **104** having the parameters as at the point **2** enters a second heat exchanger **HE2**, passes through it, and is further cooled, releasing further heat and leaves the second heat exchanger **HE2** as a stream **106** having parameters at a point **3**. Thereafter, the stream **106** having parameters as at the point **3** enters into a first heat exchanger **HE1**, passes through it, is yet further cooled, releasing yet further heat, and leaves the first heat exchanger **HE1** as a stream **108** having parameters as at a point **4**. Thus, the heat source stream **102** undergoes three heat transfers stages in heat exchangers **HE1**, **HE2**, and **HE3**. The heat from the four heat transfers stages is used to vaporize a multi-component stream **110** in the apparatus **100**.

[0030] The multi-component working fluid stream **110** having parameters as at a point **5** corresponding to a state of saturated or slightly subcooled liquid, enters into the first heat exchanger **HE1** on a shell side **112** thereof, passes through the first heat exchanger **HE1**, where it is heated by the heat source stream **106** having the parameters as at the point **3** to produce the heat source stream **108** having parameters as at the point **4**. As the heat source stream **108** travels through the first heat exchanger **HE1** heat is transferred to the working fluid stream **110** causing it to boil, releasing vapor along a length **L** of the first heat exchanger **HE1**. The produced vapor is constantly removed into a first vapor collector **VC1** via a plurality of vent lines **114** at spaced apart locations **116** along the length **L** of the first heat exchanger **HE1**.

[0031] Because in the process of boiling, temperature changes along the length of the heat exchanger, the vapor produced in different parts of the heat exchanger will have different compositions. Thus, by removing the vapor at space apart locations along the length of the heat exchanger, the composition of the vapor can be maintained substantially the same as the boiling liquid allowing substantially nucleate boiling to occur along the length of the heat exchanger.

[0032] All of the vapor removed from the first heat exchanger **HE1** is mixed in the first vapor collector **VC1** and leaves the first vapor collector **VC1** as a first vapor stream **118** having parameters as at a point **10**. Meanwhile, the liquid leaving the first heat exchanger **HE1** as a first liquid stream **120** having parameters as at a point **6** is hotter having been heated in the first heat exchanger **HE1** and has a lower proportion of the low boiling component as compared to the liquid stream **110**

having the parameters as at the point **5**. Thereafter, the liquid stream **120** having the parameters as at the point **6** is sent into a shell side **112** of the second heat exchanger **HE2**, where it is further heated and boiled by heat released by the heat source stream **104** having parameters as at the point **2** as it passes through the second heat exchanger **HE2** transferring heat to the liquid stream **120** to form the heat source stream **106** having the parameters of the point **3**, sometime referred to as the **2-3** heating step. As in the first heat exchanger **HE1**, the vapor produced in the second heat exchanger **HE2** is collected in a second vapor collector **VC2** via a plurality of vent lines **114** at spaced apart locations **116** along the length of the second heat exchanger **HE2**, and leaves the second vapor collector **VC2** as a second vapor stream **122** having parameters as at a point **11**, while the liquid leaves the second heat exchanger **HE2** as a second liquid stream **124** having parameters as at a point **7**.

[0033] The second liquid stream **124** having the parameters as at the point **7** is then mixed with another stream of liquid **126** having parameters as at a point **14**, as described below. In this embodiment of the present invention, a temperature and composition of the liquid stream **126** having the parameters **14** are substantially identical to a temperature and composition of the liquid stream **124** having parameters as at the point **7**. As result of this mixing, a combined liquid stream **128** having parameters as at a point **8** is formed.

[0034] The liquid stream **128** having the parameters as at the point **8** then passes through into a shell side **112** of the third heat exchanger **HE3**, where it boils, producing vapor which is collected in a third vapor collector **VC3**. The unvaporized liquid leaves the third heat exchanger **HE3**, as a third liquid stream **130** having parameters as at a point **9**, while the vapor produced in the third heat exchanger **HE3** is collect in the third vapor collector **VC3** and leaves the third vapor collector **VC3** as a third vapor stream **132** having parameters as at a point **12**.

[0035] The temperature of the third liquid stream **130** having the parameters as at the point **9** is a highest temperature achievable in this embodiment of the process of this invention. If the vapor collected in vapor collectors **VC1, VC2 & VC3** was not removed from the liquid streams **110, 120** and **128** during heating, then the composition of the liquid stream **130** having the parameters as at the point **9** would be equal to the composition of the stream **110** having the parameters as at the point **5** and such a stream would have been fully vaporized at the temperature and pressure corresponding to the liquid stream **130** having the parameters as at the point **9**. But because the vapor was removed as described above, the composition of the liquid stream **130** having parameters as at the point **9** is significantly leaner (*i.e.*, has a lower concentration of the low-boiling component)

than the stream **110**. The state of the liquid stream **130** is a saturated liquid.

[0036] The vapor streams **118**, **122**, and **132** having parameters as at the points **10**, **11** and **12**, respectively, are combined into a combined vapor stream **134** having parameters as at a point **13**. The stream **134** having the parameters as at the point **13** has a temperature which is substantially lower than the temperature of the third liquid stream **130** having the parameters as at the point **9**. As was noted above, the liquid stream **130** having the parameters as at the point **9** is substantially leaner than the initial liquid stream **110** having the parameters as at the point **5**. Conversely, the combined vapor stream **134** having the parameters as at the point **13** is significantly richer in the low-boiling component than the initial multi-component stream **110** having the parameters of at the point **5**.

[0037] The intermediate removal of vapor has achieved the maintenance of nucleate boiling in all three heat exchangers **HE1**, **HE2** and **HE3**. However, the produced vapor does not have the required temperature (which must be equal to the temperature of the composition of the third liquid stream **130** having the parameters as at the point **9**) or the required composition (which must be equal to the composition of the initial multi-component stream **110** having the parameters as at the point **5**) to achieve the complete vaporization of the initial multi-component liquid stream **110** having the parameters as at the point **5**.

[0038] To accomplish these thermal and compositional requirements, the combined vapor stream **134** having the parameters as at the point **13** is sent into a lower part **136** of a vertical scrubber **SC**, while the liquid stream **130** having parameters as at the point **9** is sent into a upper part **138** of the scrubber **SC**. In the scrubber **SC**, the liquid stream **130** having the parameter as at point **9** is sprayed into the **SC** and the droplets fall down through the scrubber **SC**. Meanwhile, the combined vapor stream **134** having parameters as at the point **13** moves up through the scrubber **SC**. In such a counterflow of liquid and vapor arrangement, a very intensive heat and mass transfer occurs. The liquid, as a result of such a process, becomes cooler and richer, whereas the vapor becomes hotter and leaner. At a top **140** of the scrubber **SC**, the vapor from the stream **134** comes into equilibrium with the third liquid stream **130** h aving the parameters as at the point **9** acquiring the same temperature of the stream **130** having the parameters as at the point **9** and the same composition as the initial multi-component liquid stream **110** having the parameters as at the point **5**.

[0039] This resulting vapor, leaves the top **140** of the **SC** as a fourth vapor stream **142** having the parameters as at the point **15**. Meanwhile, the liquid is collected at the bottom of the scrubber **SC**, and leave a bottom **144** of the scrubber **SC** as the stream **126** having the parameters as at the point

14.

[0040] The temperature and composition of the **SC** liquid stream **126** having the parameters as at the point **14** depends on the flow rate of the third liquid stream **130** having the parameters as at the point **9**, the larger the flow rate, the hotter and leaner the **SC** liquid stream **126** having parameters at the point **14**. Therefore, it is possible to achieve a composition and temperature of the **SC** stream **126** having the parameters as at the point **14**, which are practically the same as the composition and temperature of the second liquid stream **124** having the parameters of the point **7**.

[0041] The **SC** stream of liquid **126** having the parameters as at the point **14** is combined with the third stream of liquid **124** having parameters as at the point **7** forming the combined liquid stream **128** having parameters as at the point **8** as described above.

[0042] Referring now to Figure 1B, an alternate preferred embodiment of the apparatus of Figure 1B, generally **150** is shown, where the vapor **118**, **122** and **132** having the parameters of the points **10**, **11** & **12**, respectively, collected in the vapor collectors **VC1**, **VC2** and **VC3** are fed individually into the scrubber **SC**. In such a case, the individual vapor stream **118**, **122** and **132** must be sent into different points along a height of the scrubber **SC**. The hottest stream **132** is fed into the **SC** at an upper feed port **152** of the **SC**, the middle temperature vapor stream **122** is fed into the **SC** at a middle feed port **154** of the **SC**, and the coldest stream **118** is fed into the **SC** at a lower feed port **156** of the scubber **SC**. Such a multi-point injection arrangement would increase the efficiency of the process in the scrubber **SC**, but would require more elaborate piping. In such a case, the liquid collected at the bottom **144** of the scrubber **SC**, will be cooler and, therefore, must be sent back into the system between **HE1** and **HE2** and combined with the stream **120** having the parameters as at the point **6** instead of between the heat exchanger **HE2** and **HE3** and combined with the stream **124** having the parameters of the point **7**. The exact position of the ports **252**, **254**, and **256** will depend on the scrubber design, stream flow rates, stream compositions and other system criteria well known to ordinary artisans.

[0043] Figure 1, shows the proposes system as including three heat exchangers, however, the proposed system will function with a minimum of two heat exchangers to as many heat exchangers as may be required for a given project. Preferably, the number of heat exchangers or heat exchange units are between 3 and 12 heat exchangers with between 3 and 8 being particularly preferred with between 3 and 6 being most preferred. One with ordinary experience in the art can design a specific embodiment of this system with a number of heat exchangers as required by circumstances. In the above embodiments, the vapor removal apparatus comprises a vapor collector associated with each

heat exchanger.

[0044] Variants of the proposed system designed for work at very high temperature (*e.g.*, power plants such as nuclear or direct coal fired power systems) are shown in Figure 2A&B. Referring now the Figure 2A, another preferred system of this invention, generally **200**, is shown to include four heat transfer loops **HTL 1-4**. A saturated liquid stream **202** to be vaporized and having parameters as at a point **1** is fed into the system from a header **H**, into the first heat transfer loop **HTL1**. After being partially vaporized in the loop **HTL1**, the saturated liquid stream **202** leaves as a first mixed stream **204** having parameters as at a point **2** and enters into a drum **Dl**, where the first mixed stream **204** is separated into a first liquid stream **206** having parameters as at a point **3** and a first vapor **208** having parameters as at a point **12.** The liquid stream **206** having the parameters as at the point **3** is combined with a SC liquid stream **210** having parameters as at point **11** from a scrubber **SC** to form a combined stream of liquid **212** having parameters as at a point **4**.

[0045] The combined stream **212** having the parameter as at the point **4** is then sent into the second heat transfer loop **HTL2,** where it is partially vaporized producing a second mixed stream **214** having parameters as at a point **5**. After being partially vaporized in the second loop **HTL2**, the second mixed stream **214** enters into a second drum **D2**, where the second mixed stream **214** is separated into a second liquid stream **216** having parameters as at a point **6** and a second vapor **218** having parameters as at a point **13**.

[0046] The third liquid stream **216** having the parameters as at the point **6** is then sent into the third heat transfer loop **HTL3**, where it is partially vaporized producing a third mixed stream **220** having parameters as at a point **7**. After being partially vaporized in the third loop **HTL3**, the third mixed stream **220** enters into a third drum **D3**, where the third mixed stream **220** is separated into a third liquid stream **222** having parameters as at a point **8** and a third vapor **224** having parameters as at a point **14**.

[0047] The liquid stream **222** having the parameters as at the point **8** is then sent into the fourth heat transfer loop **HTL4**, where it is partially vaporized producing a fourth mixed stream **226** having parameters as at a point **9**. After being partially vaporized in the fourth loop **HTL4**, the fourth mixed stream **226** enters into a fourth drum **D4**, where the stream **226** is separated into a fourth liquid stream **228** having parameters at a point **10** and a vapor **230** having parameters as at a point **15**.

[0048] The fourth liquid stream **228** having parameters as at a point **10** is then forwarded to a top **232** of the **SC**. The fourth vapor stream **230** having the parameters as at the point **15**, the third vapor

stream **224** having the parameter as at the point **14**, the second vapor stream **218** having the parameters as at the point **13**, and the first vapor stream **208** having the parameters as at the point **12** are combined to from a combined vapor stream **234** having parameters as at a point **16**.

[0049] Clearly, the processes in the heat transfer loops **HTL2-4** are identical.

[0050] As in the case of the apparatus of Figures 1A&B, the combined vapor stream **234** does not have the required temperature (which most be equal to the temperature of the composition of the fourth liquid stream **228** having the parameters as at the point **10**) or the required composition (which must be equal to the composition of the initial liquid stream **202** having the parameters as at the point **1**) to achieve the complete vaporization of the liquid stream **202** having the parameters as at the point **1**.

[0051] To accomplish this requirement, the combined vapor stream **234** having the parameters as at the point **16** is sent into a lower part **236** of the vertical scrubber **SC**, while the fourth liquid stream **228** having parameters as at the point **10** is sent into the top **232** of the scrubber **SC**. In the scrubber **SC**, the fourth liquid stream **228** having the parameter as at point **10** is sprayed and the droplets fall down through the scrubber **SC**. Meanwhile, the combined vapor stream **234** having parameters as at the point **16** moves up through the scrubber **SC**. In such a counterflow of liquid and vapor arrangement, a very intensive heat and mass transfer occurs. The liquid, as a result of such a process, becomes cooler and richer, whereas the vapor becomes hotter and leaner. Near the top **232** of the scrubber **SC**, the vapor stream **234** having the parameters as at the point **16** comes into equilibrium with the liquid stream **228** having the parameters as at the point **10** acquiring the same temperature as the stream **228** having the parameters as at the point **10** and the same composition as the stream **202** having the parameters as at the point **1**. Thus, the system **200** has achieved the result of substantially complete or full vaporization of the multi-component stream **202** having the parameters as at the point **1**.

[0052] This resulting vapor, leaves an upper port **238** of the **SC** as a stream **240** having the parameters as at the point **17**. Meanwhile, the liquid is collected at a bottom **242** of the scrubber **SC**, and leave the scrubber **SC** as the stream **210** having the parameters as at the point **11**.

[0053] The temperature and composition of the liquid stream **210** having the parameters as at the point **11** depends on the flow rate of the liquid stream **228** having the parameters as at the point **10**, the larger the flow rate, the hotter and leaner the liquid stream **210** is at the point **11**. Therefore, it is possible to achieve a composition and temperature of the stream **210** having the parameters as at the point **11**, which are practically the same as the composition and temperature of the liquid stream

206 having the parameters of the point **3**.

[0054] As a result of boiling, a hot liquid stream **228** having parameters as at the point **10**, which is leaner than the initial liquid stream **202** having the parameter as at the point **1**, and a stream **234** of vapor having parameters as at the point **16**, which is cooler than the liquid stream **228** having the parameters as at the point **10** and richer than the liquid **202** having the parameters as at the point **1** is produced. These streams are then sent into the scrubber **SC**, which performs as described above and shown in Figures 1A&B to produce a fully vaporized stream **240** having a temperature substantially the same as the liquid stream **228** and a composition substantially the same as the stream **202**.

[0055] As in Figure 1B, the four vapor streams **208**, **218**, **224**, and **230** can be fed separately to the scrubber **SC** to increase its efficiency, but at a cost of additional piping and valving. Referring now to Figure 2B, another preferred embodiment of the system of Figure 2A, generally **250** is shown, but with each individual vapor stream **208**, **218**, **224**, or **230** being fed separately into the scrubber **SC.** The first vapor stream **208** having the lowest temperature is fed into the scrubber **SC** at a first and lowest vapor feed port **252**. The second vapor stream **218** having a higher temperature is fed into the scrubber **SC** at a second vapor feed port **254**. The third vapor stream **218** having a yet higher temperature is fed into the scrubber **SC** at a third vapor feed port **256**. The fourth vapor stream **218** having the highest temperature is fed into the scrubber **SC** at a fourth and highest vapor feed port **258**. The exact position of the ports **252**, **254**, **256** and **258** will depend on the scrubber design, stream flow rates, stream compositions and other system criteria well known to ordinary artisans.

[0056] As shown above, the system of this invention illustrated in Figures 1A&B allows maintenance of nucleate boiling because the heat exchangers are equipped with vapor collectors, where boiling occurs and at the same time, allows for the production of vapor having a desired temperature and composition. This result is achieved by recycling liquid through the chain of heat exchangers equipped with vapor collectors and the scubber. In the system of this invention illustrated in Figures 2A&B, maintenance of nucleate boiling in the heat transfer loops is achieve by equipping each heat transfer loop with a drum separator and in conjunction with the scruber allows boiling occurs and at the same time, allows for the production of a multi-component vapor having a desired temperature and composition.

[0057] Referring now the Figure 3, a preferred a heat extraction and energy production facility of this invention, generally **300**, is shown to include a multi-component fluid vaporization apparatus

of this invention **302**. The apparatus **302** includes an heat source input **304** and an heat source output **306**, where the input **304** inputs a heat source **308** shown here as an input heat source stream, but can be any other heat source and where the output **306** outputs a spent heat source **310** shown here as a spent heat source stream. Of course, if the heat source was focused sun light or other forms of electromagnetic radiation, then the input **304** would input light and the output **306** would output unused light.

[0058] The apparatus **302** also includes a liquid multi-component working fluid input **312** and a vapor multi-component working fluid output **314**, where the liquid input **312** inputs an input liquid multi-component working fluid stream **316** and where the vapor output **314** outputs a final vapor multi-component working fluid stream **318**. The liquid input stream **316** is output from an energy conversion unit **320** through a conversion unit liquid output **322**, while the final vapor stream **318** is input to the energy convention unit **320** through a conversion unit vapor input **324**. The energy conversion unit **320** extracts thermal energy from the final vapor stream **318** to produce the input liquid stream **316** and useable energy such as electrical energy or the like. Such energy conversion units can include any energy conversion unit known in the art including those described in United States Pat. Nos.: 4,346,561; 4,489,563; 4,548,043; 4,586,340; 4,604,867; 4,674,285; 4,732,005;4,763,480; 4,899,545; 4,982,568; 5,029,444; 5,095,708; 5,440,882; 5,450,821; 5,572,871; 5,588,298; 5,603,218; 5,649,426; 5,754,613; 5,822,990; 5,950,433; 5,953,918; and 6,347,520; in co-pending United States Pat. Appln. Ser. Nos.: 10/242,301 filed 12 September 2002; 10/252,744 filed 23 September 2002; 10/320,345 filed 16 December 2002, and 10/357,328 filed 03 February 2003, incorporated herein by reference.

[0059] Thus, the processes and apparatuses (systems) provide for the full vaporization of multi-component fluids, the maintenance of high heat transfer coefficients in the boilers, and the protection of the boiler tubes from overheating in high temperature boilers or other higher temperature heat transfer systems.

[0060] All references cited herein are incorporated herein by reference. While this invention has been described fully and completely, it should be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. Although the invention has been disclosed with reference to its preferred embodiments, from reading this description those of skill in the art may appreciate changes and modification that may be made which do not depart from the scope and spirit of the invention as described above and claimed hereafter.